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(54) Title: METHOD OF HANDING OVER MOBILE STATIONS IN A GENERAL PACKET RADIO SERVICE (GPRS) RADIO TELECOMMUNICATIONS NETWORK

(57) Abstract: A method of improving cell change procedures within a General Packet Radio Service (GPRS) network to reduce the handover interruption time while keeping the delays to affordable values for real-time payload services. The data stream interruption is reduced at the air interface level and the core network level. Improvements at the air interface are achieved by reducing the system information retrieval time and pre-allocating the radio resources prior to the MS accessing the new cell. Improvements within the core network are achieved by shortening the inter-SGSN Routing Area Update interruption interval and implementing low latency delay-sensitive requirements and shaping packet traffic for premium traffic.

METHOD OF HANDING OVER MOBILE STATIONS IN A GENERAL PACKET RADIO SERVICE (GPRS) RADIO TELECOMMUNICATIONS NETWORK

PRIORITY STATEMENT UNDER 35 U.S.C. § 119(e) & 37 C.F.R. § 1.78

This nonprovisional application claims priority based upon the prior U.S. provisional patent application entitled, "Method of Handing Off Terminals in a General Packet Radio System (GPRS) to Support Voice Services", application number 60/140,346 filed June 21, 1999, in the names of Francis Lupien, Marlene Yared, and Jean-Francois Bertrand.

BACKGROUND OF THE INVENTION

Technical Field of the Invention

This invention relates to telecommunication systems and, more particularly, to a system and method of handing over mobile stations in a General Packet Radio Service (GPRS) radio telecommunications network to support voice services.

Description of Related Art

In existing radio telecommunications networks, a cell change or handover procedure in GPRS is executed when a Mobile Station (MS), which is transmitting and receiving user data payload while in GPRS mobility management (GMM) state READY, roams into the coverage area of a neighboring cell, acquires service in that cell, and resumes data transmission. As the MS roams and changes cells while in READY state, the network tracks mobility information by updating the MS's serving routing area (RA) and cell. The process of updating cell information and routing area information is executed through standards defined by GMM procedures.

As defined in the GPRS specification, when a mobile station changes cells, it must inform the network of its location. There are three types of cell change:

1) within one routing area (cell update);
2) between two routing areas but within one Serving GPRS Support Node (SGSN) area (intra-SGSN routing area update); and

3) between two SGSN areas (inter-SGSN routing area update).

Delay in the real time traffic flow is common to all types of cell change. Interruptions arise due to the execution of various functions currently prescribed in the GPRS standard for radio access, radio resource allocation, location update network signaling, and inter-SGSN link handling.

Overview of the Current System

When a MS in READY state roams to a new cell belonging to a different location area (LA) or SGSN service area, the data stream is interrupted from the time the MS leaves the serving cell until the GPRS mobility management (GMM) procedures terminate. When the MS changes cells, it must abort any temporary block flow (TBF) and cease transmission on the uplink and downlink. When the MS switches to the new cell, it must read all system information messages before making a request for packet resources (new TBF). The typical time for the MS to switch to the new cell may be 40-60 ms.

In the intra-SGSN and inter-SGSN case, the MS must update its mobility context in the Packet Switched (PS) network by sending a Routing Area Update Request message. A new TBF resource must be used to send the Routing Area Update Request message. The estimated time to establish a new uplink TBF and send the Routing Area Update Request Message is 100-150 ms. After the Routing Area Update Complete Message is sent, the mobile must then reestablish an uplink TBF (100-150 ms) and a downlink TBF (60-100 ms) to resume data transfer.

In addition, the current mobility management procedures are designed to minimize packet loss while a MS performs a cell change within and across SGSN borders, and hence are biased towards loss-sensitive traffic types. Loss minimization is achieved by minimizing the loss of Logical Link Control (LLC) packets during the change of traffic flow connections between the old and new SGSN, and is accomplished through a buffer transfer and associated synchronization of LLC transmission states. The content of the old SGSN buffer is transferred to the new SGSN, including packets that were not acknowledged and packets received at the old SGSN before the transfer of control to the new SGSN was completed. In the inter-SGSN handover case, in addition to the above steps, the SGSN context and the Packet

Data Protocol (PDP) context must be updated in the packet-switched (PS) domain. This procedure includes the Home Location Register (HLR) location update process, the transfer of mobility context and buffers between the SGSNs, and the establishment of the new GPRS Tunneling Protocol (GTP) link. Currently, the packets are tunneled between the old SGSN and the new SGSN until the link is set up.

Additionally, if the subscriber is IMSI attached, the mobility management context must be updated in the circuit-switched (CS) domain. Assuming that each network signaling procedure may have a delay budget of 100-200 ms, this yields an additional 1.1 to 2.2 seconds delay. Furthermore, approximately 50 ms is needed for the SGSN to process the RA Update Request and send the RA Update Accept.

While all three types of cell changes induce some measure of interruption in real time traffic flow, the inter-SGSN cell change yields the longest interruption time. The total interruption time for an inter-SGSN routing area update is approximately 3-4 seconds.

SPECIFIC PROBLEM AREAS

While the preceding section broadly outlines the procedures associated with handing off mobile terminals in GPRS to support voice services, it is necessary to explain more thoroughly specific problem areas that induce delay in the existing system. FIG. 1 is a simplified block diagram illustrating the existing GPRS system. A packet data network (PDN) 1 having terminal equipment (TE) 1a is connected to the network through a gateway GPRS support node (GGSN) 2. A mobile station (MS) 12 is connected to the network through a serving (Old) base station system (BSS-1) 10 and a serving GPRS support node (SGSN-1) 6. The BSS-1 also connects the MS to a serving (Old) mobile switching center/visitor location register (MSC/VLR-1) 8. The SGSN-1 is also connected to a home location register (HLR) 5, an equipment identity register (EIR) 3, and to a target (New) SGSN (SGSN-2) 7. The SGSN-2 is, in turn, connected to a New BSS (BSS-2) 11 and a New MSC/VLR (MSC/VLR-2) 9. The network may also be connected to other Public Land Mobile Networks (PLMN) 4.

FIG. 2 is a message flow diagram illustrating the messages utilized in the existing inter-SGSN handover process. As shown in FIG. 2, the delay problem can be broken down into the following areas:

1) Cell re-selection procedures;
2) Establishment of the Uplink and Downlink TBF;
3) Establishment of the GTP link between the new SGSN 7and the Gateway GPRS Support Node (GGSN) 2 (steps 20 – 27);
4) Updating location information in the HLR 5 for GPRS attached mobiles (steps 28 – 33);
5) Performing GPRS security procedure (steps 23a and 23b);
6) Updating the mobility management context in the circuit switch domain if the mobile station is IMSI attached (steps 34 – 41);
7) Handling of delay-sensitive packets (versus loss-sensitive packets); and
8) Completion of the RA Update process (steps 42-44).

Delay inducing problem areas within GPRS can be broadly categorized into two distinct types – MS Centric relating to mobile station related delays, and Network Centric relating to core network delays. Mobile station delays are related to the air link protocol and air interface delays such as those resulting from cell re-selection procedures and in the establishment of the Uplink and Downlink TBF. The air link includes delays from the physical RF link layer, the physical data link layer (sub-channeling (PBCCH, PACCH, PDCH, PCCCH, etc.)) and the Media Access Control/Radio Link Control (MAC/RLC). Specific core network delays exist in GTP Link establishment procedures, policing functions, and admission control.

<u>MS Centric Delays</u>

<u>MS Cell Re-selection</u>: The MS Cell Re-selection Procedure is described in the GSM specifications 04.60 and 05.08. The MS Cell Re-selection Procedure is controlled by the parameter Network_Control_Order. It is sent on the Broadcast Control Channel (BCCH) as well as on the common control or Packet Associated Control Channels (PACCH). Consequently, the cell re-selection mode can be set for all mobile stations but can be changed for a particular mobile station. The available settings for the parameter are:

NC0: MS control (autonomous cell re-selection);
NC1: MS control with measurement reports sent to the network; and
NC2: Network control with measurement reports sent to the network.

While in packet transfer mode, an MS constantly measures the signal strength of its neighboring cells and of the serving cell. Once it has determined the best candidate target cell, based on signal strength measurements, the MS then acquires the target cell's system access information. The MS may continue its operation in packet idle or packet transfer mode in the old serving cell, while acquiring certain system information for the target cell. The MS may suspend its TBF in order to read the necessary information message on the BCCH and Packet Broadcast Control Channel (PBCCH) of the target cell. When the MS performs this procedure, the network is not made aware of the MS's actions, and therefore the MS may miss downlink packets. It takes approximately 20 ms to read a system information message, and taking retuning time into account, the maximum loss is 2 blocks or 40 ms. Assuming one PSI/SI message is read at a time, and the MS returns to the serving cell between reading attempts, the maximum time for loss of packets would be 40 ms for each reading attempt. This operation could continue for up to 5 seconds. The MS may move to the target cell without having completely read all of the necessary system information messages. This may be due to its multi-slot capabilities or that (according to GSM 05.08) the current serving cell radio conditions are no longer fulfilled.

Currently, the minimum requirements for an MS to move to the new cell are:

- The MS starts to receive information on the PBCCH of the target cell (if the target cell contains a PBCCH);
- The MS has received SI-13 on the BCCH of the target cell indicating that the cell supports GPRS (if there is no PBCCH in the target cell); and
- Required radio conditions (according to GSM 05.08) for the old cell are no longer fulfilled.

If the target cell supports GPRS, then the MS may not perform a packet access. The following paragraphs describe the information that the MS must decode before making a packet access request.

If the target cell contains BCCH only, the MS does not perform packet access in the target cell or enter the packet transfer mode until it has performed a "complete acquisition" of the BCCH messages. In this case, the MS must acquire a PSI-1 message (20 ms) and make at least one attempt to receive other SI messages that may

be scheduled within one TC cycle on the BCCH. The time to complete the entire transaction is almost 2 seconds. (See GSM 05.02 para 6.3.1.3: TC = (FN div 51) mod 8, FN = Frame Number; Max 8 multi-frame lengths ⇒ 8 × 235 ms = 1.9 seconds).

If PBCCH exists in the target cell, the MS delays the start of receiving information on the PBCCH until the first occurrence of PSI-1 in block B0. If reception of PS-1 and PS-2 fails, the MS can continue in the old cell until the next occurrence of PSI-1 in block B0. The mobile does not perform packet access in the target cell or enter the packet transfer mode until it has performed a "complete acquisition" of the PBCCH messages. In this case, the MS first acquires a PSI-1 message (20 ms), then acquires a consistent set of PSI-2 messages (min 1 msg., max 8 msg. ⇒ 20-160 ms), and finally attempts to receive the complete set of PSI messages on the PBCCH (min 4 msg. ⇒ 80 ms).

The scheduling of the packet system information messages on the PBCCH is completely network-determined. The network divides the messages into high repetition rate and low repetition rate messages, and can use a repetition cycle that is anywhere from 1 to 16. In the worst case scenario, wherein the repetition cycle is 16, the maximum time it takes the MS to read all PSI messages is almost 4 seconds. (16 × 235 ms = 3.7 seconds) (See GSM 05.02 para 6.3.2.4). However, even if the cycle is set to 8 (as in the BCCH case) and the messages are scheduled so that the complete set is read in one cycle, the time to read is still almost 2 seconds.

Set-up of Uplink and Downlink TBF: In the present GPRS system, a temporary block flow (TBF) must be established before any user data can be sent. The TBF in the uplink and in the downlink are set up separately. It is estimated to take 100-150 ms to set up an uplink TBF. It is estimated to take 60-100 ms to set up a downlink TBF.

In addition, the GPRS specifications state that the current TBF must be abandoned and a new TBF requested if there is a change in priority. Mobility management messages, such as the Routing Area (RA) Update message, have a higher priority than user data. Therefore, before the RA Update sequence, a TBF must be established, and after the procedure is finished, a new TBF must be established to resume the data flow.

Network Centric Delays

GTP Link Establishment: The current GPRS baseline text defines a procedure for combined inter-SGSN RA/LA updates which is not appropriate to support real-time service performance requirements. The data stream is interrupted from the time the MS leaves the serving cell until the RA Update terminates with the RA Update complete signal. Location update handling includes the following:

1) The SGSN Update Location process to the HLR, Insert Subscriber Data, and location cancellation; and

2) The location update from the SGSN to the Mobil Switching Center/Visitor Location Register (MSC/VLR), the MSC/VLR location update to the HLR with associated insertion of subscriber data, and location cancellation.

The RA Update procedure assumes the following functions are performed following either an MS-controlled or network-controlled (*i.e.*, Base Station System (BSS)) cell re-selection:

1) GTP Link Establishment

- SGSN context transfer and GTP link set-up between the old and new SGSN for inter-SGSN tunneling.
- PDP context transfer for GTP link set-up between the Gateway GPRS Support Node (GGSN) and the new SGSN.

For a cell change controlled by the MS, packet delays in mobile terminated calls may range between 410 ms and 660 ms for packets arriving during the RA Update procedure. Packets arriving later will suffer delays of 260 ms to 450 ms due to the priority transmission of packets accumulated during the RA Update interruption and the Upd PDP context procedure. In mobile originated calls, the total packet delay may be in the range of 550 ms to 910 ms, of which 100 ms to 200 ms is attributable to the GTP link establishment procedure.

For a cell change controlled by the network, packet delays in mobile terminated calls may range between 310 ms and 460 ms for packets arriving during the RA Update procedure. Packets incoming to the new SGSN from the GGSN after the RA Update procedure are buffered and await transmission due to the priority transmission of packets already accumulated. The delay may be quantified as 170 ms to 250 ms.

In mobile originated calls, the total packet delay may be in the range of 450 ms to 660 ms. The delay is due to buffering at the old SGSN until the inter-SGSN tunneling link is established (200 ms to 400 ms) and buffering which may occur at the TE in order to minimize packet loss during preemption/interruption of packets transferred at the RA Update (250 ms to 360 ms).

2) Security procedures: authentication and potential fetching of security data from the Authentication Center (AuC) (security triplet). The security function during RA Update may involve the following optional steps:

- MS authentication request (the security triplet(s) may need to be obtained from the HLR);
- User identity confidentiality through reallocation of a new P-TMSI at any time (included as part of the RA-update exchange);
- Identity (IMEI) check procedures (the SGSN may decide to check the IMEI against the EIR); and
- Reset of Ciphering Key: The Kc[SN] (serial number encrypted using Kc) and the ciphering algorithm is passed to the MS as the authentication request.

It is to be noted that execution of the above security procedure during the RA update with potential HLR query for security triplet(s), will further increase the RA update interruption time and thus data transfer delay.

3) MS location handling in the GPRS network

- New SGSN Location update to HLR;
- Subscriber data update from the HLR to the new SGSN; and
- Location cancellation of the old SGSN location.

4) If the subscriber is IMSI attached,

- New location update from the new SGSN to the associated MSC/VLR;
- New MSC/VLR Location update to the HLR;
- Subscriber data update in the new MSC/VLR; and
- Location cancellation of the old MSC/VLR location.

5) TMSI reallocation.

As stated previously the total interruption time may total three to four seconds.

Policing Functions: In systems that only support best efforts (loss sensitive) services, the associated policing functions (if present at all) do not provide the characteristics needed for real-time payload services. Current policing functions are, at best, based on simple traffic shaping mechanisms for best effort traffic only. The shaping is meant to forge a "bursty" data stream into a desired traffic profile. Typically, for a data stream session, this is done through queuing of "bursty" incoming packets to impose a constant delay within the specified traffic profile. The packets accumulate in a queue/buffer at a certain "bursty" rate, and are then removed from the queue at a constant rate, imposing a constant delay. The policing function consists of identifying packets that fall out of profile parameters, typically when the packet rate exceeds the profile rate limit.

Traffic shaping functions are typically implemented in edge nodes. If the radio access network, the operator network, and the ISP network are considered separate domains, then the SGSN, GGSN, and RNS/RNC can be edge nodes. In the scope of GPRS Ph. 1, the SNDCP/LLC implements such functions.

Admission Control: Today's GPRS phase has no admission control besides the QoS negotiation at PDP context activation.

A consequence of the various interruptions, whether MS Centric or Network Centric, is the degradation of the delay performance. While it has been demonstrated that the user does not perceive any difference for interruption times less than 100 ms, a critical problem arises if the interruption lasts for more than a few tens of seconds since service interruption time in this range is not acceptable for low latency and delay-sensitive applications such as real-time speech.

The known prior art neither teaches nor suggests a solution to the aforementioned deficiencies and shortcomings such as that disclosed herein.

In order to overcome the disadvantages of existing solutions, it would be advantageous to have a method of introducing new capabilities within the GPRS system to better handle the handover procedure for delay-sensitive type traffic thereby reducing the handover interruption time while keeping the delays to affordable values for the real-time payload services in a PS GPRS network. The present invention provides such a method.

SUMMARY OF THE INVENTION

The present invention is a method of improving cell change procedures within the GPRS system to reduce the handover interruption time while keeping the delays to affordable values for real-time payload services in a PS GPRS network. The method consists of procedural mechanisms which reduce the data stream interruption at the air interface RLC/MAC level and shorten the inter-SGSN Routing Area Update interruption interval at the core network level.

Improvements at the air interface are achieved by reducing the system information retrieval time and pre-allocating the TBF prior to the MS accessing the new cell/BSS. The system information retrieval time is reduced by sending system information messages about the target cell for handover on a control channel in the MS's current serving cell. A Packet Associated Control Channel (PACCH) may be utilized as the control channel for sending such system information messages. Additionally, silent periods, when no speech is in progress, are utilized for sending system information messages. Where the MS is capable of supporting multiple time slots, system information messages are sent on a different time slot than the time slot carrying the speech. Pre-allocation of the TBF is accomplished by reserving a TBF in the target cell for the MS prior requesting a handover. Reserving a TBF in the target cell for the MS prior to requesting handover may also include the following: reserving resources in the target cell for the MS based on the MS's quality of service profile; modifying a Packet Cell Change Order message to assign the TBF in the target cell to the MS; and/or modifying a Packet Time Slot Reconfigure message to assign the TBF in the target cell to the MS.

Improvements within the core network are achieved by utilizing low latency delay-sensitive requirements and shaping packet traffic for premium traffic (e.g., speech). Implementing low latency delay-sensitive requirements, instead of loss-sensitive requirements, provides a more efficient approach to packet dropping, redirection, and buffering. A combination of procedural mechanisms is utilized to improve traffic shaping. The GTP link establishment procedure is improved by modifying the GTP link handling logic so that mobility management procedures are delayed until after handover. Location update procedures and security functions are

postponed until after the handover is completed. The current inter-SGSN tunneling mechanism may also be removed. In addition, packet multicasting or "soft handover"-like mechanisms, between the GGSN and the serving and target SGSN are utilized to improve handover performance.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be better understood and its numerous objects and advantages will become more apparent to those skilled in the art by reference to the following drawings, in conjunction with the accompanying specification, in which:

FIG. 1 (Prior Art) is a simplified block diagram illustrating the existing GPRS system;

FIG. 2 (Prior Art) is a message flow diagram illustrating the messages utilized in the existing inter-SGSN handover process;

FIG. 3 is a simplified functional block diagram illustrating the traffic shaping function for delay-sensitive and loss-sensitive traffic requirements;

FIG. 4 is a message flow diagram illustrating the messages utilized in an improved method of MS-controlled cell change;

FIG. 5 is a message flow diagram illustrating the messages utilized in a first embodiment of an improved method of Network-controlled cell change;

FIG. 6 is a message flow diagram illustrating the messages utilized in a second embodiment of an improved method of Network-controlled cell change; and

FIG. 7 is a message flow diagram illustrating the messages utilized in a third embodiment of an improved method of Network-controlled cell change.

DETAILED DESCRIPTION OF EMBODIMENTS

The preferred embodiment of the present invention is derived from the implementation of a plurality of optimization procedures to reduce the handover interruption time. It is, therefore, necessary to discuss the possible optimization solutions to delay-inducing problem areas within GPRS prior to describing the preferred embodiment of the present invention.

MS Cell Re-Selection: The present invention improves the MS Cell Re-

selection Procedure by sending PSI-1 and PSI-2 information, or SI-13 and any other system information messages about the target cell, on the old serving cell's common control channel or Packet Associated Control Channel (PACCH). This procedure reduces the cell re-selection time and the loss of downlink radio blocks on the serving cell.

The maximum amount of system information messages sent on the BCCH is ten (10). Each message takes approximately 20 ms to transmit. Therefore, it requires a utilization of the PACCH for a maximum total of 200 ms to transfer all of the system information messages. These do not have to be sent all at once, but can be multiplexed within a 5-second period (the cell re-selection period).

Likewise, the amount of packet system information messages sent on the PBCCH ranges from 4 to 28. Each message takes approximately 20 ms to transmit. Therefore, it requires a utilization of the PACCH for a total of 80-560 ms to transfer all of the system information messages. These do not have to be sent all at once, but can be multiplexed within the 5-second cell re-selection period. The present invention may also send the messages in such a way as to minimize the disruption to the speech or other real-time payload. For example, messages may be sent during silent periods or on another time slot if the mobile station's multi-slot capabilities permit.

The effect of sending PSI-1 and PSI-2 information, or SI-13 and any other system information messages about the target cell, on the old serving cell's common control channel or PACCH is that the system information retrieval time on the target cell is reduced to zero if a change in the broadcast channel information has not occurred from the time the terminal received the SI messages on the old serving cell until it resynchronizes on the new cell. The time for the cell change therefore is reduced to only the resynchronization time.

Furthermore, to support the concept of network-assisted system information retrieval, the serving BSS/RNC has to obtain the information from the target cell's BSS/RNC either directly or via their respective SGSNs. In a network-controlled cell re-selection mode (NC2), the network selects the target cell based on the information sent by the MS in the measurement reports. In a MS-controlled cell re-selection mode

(NC0), the MS determines the target cell. However, the MS can then request the target cell's system information from the network.

Set-up of Uplink and Downlink TBF: To reduce the TBF set up time for a real-time application handover, the network may pre-reserve the TBF in the target cell so that the serving cell can forward the necessary information to the mobile station. In the present invention, two RLC/MAC control messages are modified and used by the network in a handover situation to assign a TBF to a mobile station. For example, the existing MAC control messages (*i.e.*, Packet Cell Change Order and Packet Time Slot Reconfigure) can be modified and used for a handover order. Alternatively, a new message can be created.

The Packet Cell Change Order message is used to order the MS to another cell. It contains information elements necessary to identify the BCCH of the target cell (*i.e.*, BSIC + BCCH frequency). It does not contain the information elements required for frequency hopping, and it does not contain any reference to a specific packet data traffic channel in the target cell.

The Packet Time Slot Reconfigure message is used to reassign the mobile to another packet data channel within the same cell. It contains frequency and time slot information for the target packet data channel as well as the TBI to be used in the uplink and/or downlink. The message is designed to offload the mobile station to another packet resource within the same cell and therefore does not include any Broadcast channel information.

The present invention creates a combination of the above two messages. Either one may be modified to include the required information elements or a completely new message may be created. The time for this transaction is estimated as:

- receive "Cell Change / TS Reconfigure" order – 20 ms
- retune a new cell – 5 ms
- send shortened access on new cell – 5 ms
- receive Time Alignment information from system – 20 ms

In summary, this procedure reduces the TBF set up time from the current 60-150 ms down to 50 ms.

To support the concept of pre-assignment of resources, a form of resource

reservation must be used. This has the added benefit of guaranteeing resources in the target cell. Resource reservation based on the mobile station's Quality of Service (QoS) profile can also be used. Naturally inter-BSS/RNC communications are necessary for this implementation. The communications can be between the BSS/RNCs directly or via their respective SGSNs. This concept is easily supported in a network-controlled cell re-selection mode since the target cell is selected by the network based on the measurement reports sent in by the mobile station. The concept can also be supported in a MS-controlled cell re-selection mode, but it is a little more complex. In this case, the mobile station selects a target cell and requests the network to reserve resources for it.

According to current specifications, any mobility management or signaling procedure causes the release of the TBF used for real-time payloads (e.g., speech). Possible modifications to the specifications could include assigning the same or higher priority to signaling traffic that is used for real-time traffic. Alternatively, the performance of mobility management procedures may be delayed until after the handover process is completed so as to reduce the interruption time. The start of the mobility management procedure may be controlled by a timer which specifies the time interval between the two events. The procedure for of delaying the mobility management procedure until after the call completion is discussed later.

Optimizing Routing Area Information Flows: The present invention includes two methods for optimizing Routing Area (RA) information flows, both of which involve delaying certain functions until after the handover process is completed.

a. Delaying the GPRS-GSM/ANSI-41 Location Update Procedures; and

b. Delaying the Security Functions.

If the Location Update Procedures are delayed, the location update handling in the GPRS-GSM/ANSI-41 network is completed as soon as the relevant subscriber SGSN context has been updated to the new SGSN, and the relevant PDP contexts and GTP have been updated in the new SGSN and GGSN. Inherent in this method are some foreseeable problems.

The first problem is that an additional Location Area Update Accept message is returned to the MS to transfer the result of the Location Update response received

at the new serving SGSN. This introduces an extra interruption of the real-time payload, but the delay can be minimized by avoiding the reallocation of a TBF. Although this is a disadvantage, it may be outweighed by the advantage of minimizing data-transfer delay in the combined RA/LA update situation.

The second problem is that the response from the network is also delayed with respect to the point in time when the real-time payload resumes. Normally, the mobility management procedure triggered by the RA Update is not completed until the location update process has terminated. In the present invention, the scope of GMM procedures associated with GMM state transitions are modified. In case of failure of either of the location update processes, there is a potential dropped call situation (*e.g.*, a rejected location update) or, the MS may be required to make a new GPRS attach or new PDP context activation, as indicated by the SGSN in the SGSN-initiated GPRS Detach procedure. In any case, the reason for the failure justifies that the call be aborted. There is a drawback due to the misuse of handover resources in such a case. A fallback procedure must then be implemented to send the MS back to the old SGSN. However, this scenario has a low likelihood of occurrence.

The third problem is that there is an increased likelihood that incoming circuit-switched calls may be delivered to the wrong MSC/VLR due to delays in updating the MSC/VLR location and the SGSN-MSC/VLR association. These calls could not be completed as specified by the subscriber profile (*e.g.*, CAW, TRN, TRB, *etc.*). It should be noted that this situation does not apply in a circuit-switched network since the Mobility State is not changed at inter-MSC handover.

If, instead of delaying the Location Update Procedures, the Security Functions may be delayed in order to reduce the interruption time for the RA updates. This is achieved by postponing optional security procedures until after data transfer resumes. During handover, the SGSN may choose not to perform any of the security procedures. All of the security parameters are maintained as they were before handover, and the authentication triplets have already been downloaded into the new SGSN as a part of the SGSN-context transfer. The SGSN and the MS continue to use the same ciphering algorithm as before the handover. Since TLLI/P-TMSI reallocation is already a part of the RA Update procedure, there is no need to duplicate this procedure by having a

separate P-TMSI reallocation procedure. The only security procedure left is the identity check, which does not have to be performed during handover. If a signaling exchange with the EIR occurs, handover delay increases. While postponing these security procedures may further increase the likelihood of delayed failure discovery, and introduce additional interruption of the real-time payload, this can be minimized by avoiding the reallocation of a TBF.

Thus, in the present invention, the GMM mobility context handling (04.08) is updated to extend the mobility procedure or change the Mobility Context State handling after the RA Update is completed. It is unlikely that the failure of the HLR location update procedures can be avoided; therefore, the MS may have to be redirected to the old SGSN. The security procedures can be postponed till after the RA update procedure terminates and data transfer resumes. The effect of the above procedures is to avoid the reallocation of TBF and thus keep the interruption time to a minimum.

In order to handle the interaction of CS services with the RT voice service in the packet-switched domain, one of the following approaches can be taken:

1. Provide for extra functionality between the CS and PS networks:
    - Mark subscribers "Busy" at the MSC/VLR when a RT voice call is on-going;
    - Allow for rerouting of calls from the PLMN to the VoIP gateway/network; and
    - Allow for the execution of other services in the PLMN through interwork with the VoIP Network.
2. Provide for service handling through a service convergence layer:
    - The IP paradigm allows for handling of new applications and services outside of the traditional infrastructures. Tracking of the subscriber's location in the TDMA circuit switched or RT packet-switched network can be handled by a service layer VAS (value added service) function. This allows, for instance, the delivery of incoming ANSI-41 PSTN/PLMN voice calls to the RT IS-136HS VoIP infrastructures where the subscriber is active (*e.g.*, a mobility gateway can handle

ANSI-41 call delivery and other service interaction when the MS is located in the RT PS network).

- All RT services are provided from the service layer, so they appear the same on all access networks which are a part of the IP network.
- ANSI-41 services such as basic, supplementary, and WIN services may be implemented/replicated (either fully or in part) in the service layer, as value added service to existing IP services (VAS voice services). Thus, the HLR, SCP, and Special Resource Functions (SRF) may be functionally mapped to IP-specific associated functionality, although the mechanics of implementation of the services may be different from that implemented over ANSI-41.

Packet Dropping Policy: FIG. 3 is a simplified functional block diagram illustrating the traffic shaping function for delay-sensitive and loss-sensitive traffic requirements. Profile policing is performed at 45 for loss-sensitive traffic such as Best Effort traffic which is then buffered at 48 and 49. For delay-sensitive traffic such as speech and RT streaming, the packets that do not adhere to the profile are dropped at 46. The others are buffered at 47 and 49. Important considerations for determining the criteria for dropping packets include the following:

a. Shaping for real-time service requires that the ordering be preserved, especially when dropping a packet;

b. Compression/decompression works synchronously and needs to resynchronize when packets are dropped; and

c. Encryption, when state driven, may also need to be resynchronized.

As discussed above, the handover interruption has the effect of a faster increase in the number of queued packets per session in the associated buffer. Typically, a queuing approach based on the "leaky bucket" is used at 46. A variation of the WFQ algorithm can be used or, as an alternative, a less complex method can be used which consists of time-stamping the packets in order to calculate the rate of packet queuing in comparison with the profile/service specification.

Admission Control Improvements: The present invention includes two

procedures for improving Admission Control. First, through the use of a soft reservation after call setup, if a neighboring cell is found to be part of a different service area (different LAI), inter-BSS or inter-SGSN, the MS issues a request to the network to perform a pre-allocation of resources to the MS. Resources may be requested in the targeted BSS and/or SGSN through inter-BSS communications or inter-system (SGSN) communications. The allocation of resources may be valid for a certain amount of time as determined by a timer in the MS or the network.

The second procedure consists of a QoS negotiation after handover. At handover, it may be impossible to allocate the QoS level negotiated/allocated to the old SGSN. A temporary QoS fall back in the GPRS core and radio access networks may be effected at handover. It takes too long to renegotiate the QoS through all protocol layers up to the application level and with the peers residing somewhere in the network. Subsequent QoS fall forward must be handled with a QoS renegotiation procedure between the MS, radio access network, and core network only, based on the changed load situation in both the radio network and the core network.

In order to support the TBF pre-assignment, the network can reserve the radio resources in the target cell prior to the handover. In this embodiment of the present invention, the resource reservation is also used to relay the offered quality of service of the target cell to the MS. This gives the MS the ability to renegotiate the QoS in the event that the original service QoS cannot be satisfied.

Embodiments of GPRS Network Logic Improvements

As discussed in the previous sections, all cell change procedures require mechanisms which reduce the data stream interruption at the air interface RLC/MAC level. This can be accomplished by:

- Reducing the system information retrieval time by providing the target cell's system information in the serving cell; and
- Pre-allocating the TBF prior to the MS accessing the new cell/BSS.

The core network implements low latency delay-sensitive requirements instead of loss-sensitive requirements which provide:

- an efficient packet dropping approach; and

- an efficient packet redirection and buffering approach.

The core network should also implement traffic shaping for premium traffic. Specific improvements include:

- Removing all or part of the tunneling mechanism;
- Delaying the security functions;
- Defining a new GTP link handling logic;
- Utilizing packet multicasting or "soft handover" mechanisms between the GGSN, the serving SGSN, and the target SGSN;
- Delaying the circuit-switched domain mobility management update until after the handover or the call is completed; or
- A combination of all of the above.

The SRNS relocation procedure is similar to the GPRS Network-controlled cell change procedure. Therefore, the proposed solution may also be applicable for the SRSN relocation problem.

The following embodiments of the present invention assume that traffic shaping is implemented in the SGSN and that the security and mobility management context updates are delayed until after the handover. Modified GTP link reestablishment procedures are presented.

<u>Improvements Specific to MS-Controlled Cell Change</u>: The initiation of the inter-SGSN tunneling and security functions are removed from the RA update procedure, thereby reducing the delay overhead of the RA update procedure. Speech or other real-time payload packets may be lost with the inter-SGSN tunneling being removed. Packets arriving after the RA Update will not be delayed. The complexity of Inter-SGSN tunneling and buffer synchronization is thus avoided at the expense of real-time packet loss. However, for low latency and delay-sensitive traffic types, dropping of packets may be an unavoidable reality. Real-time payload packets with an end-to-end delay on the order of the interruption time may be considered being outside of the traffic profile requirements, and may be ignored totally or in part. With this improvement, the interruption time is reduced, realizing that some of the oldest packets will be dropped, in addition to those not delivered by the old SGSN after the MS has left the old serving cell. For MS terminated packets, the maximum

interruption is now on the order of 300 ms instead of up to 600 ms in the original scenario. This may represent up to an extra 200 ms of loss for a real-time payload.

The execution of postponed security procedures causes an interruption since the required signaling is still assumed to have a higher priority than traffic (GPRS/GSM 4.08), which results in suspending traffic during the procedure. This interruption should be shorter than an inter/intra-SGSN RA Update. It is also assumed that the TBF used for the RA Update can be used for the Security functions.

FIG. 4 is a message flow diagram illustrating the messages utilized in an improved method of MS-controlled cell change. The signaling takes place in a GPRS network in which the nodes have been modified to recognize certain modified messages. Alternatively, the order of standard procedures may be altered in order to move some procedures that are not time-sensitive to a later time after data transfer is resumed.

At 50, Mobile Station (MS) 112 sends an RA Update request to a New SGSN 107. The New SGSN sends an SGSN context request 51 to an Old SGSN 106. The Old SGSN responds with an SGSN context response 52. The New SGSN then sends an RA Update 53 to the MS. The transfer of data is then resumed at 54. At 55, a PDP context update request is sent from the New SGSN to a GGSN 102, and the GGSN returns a PDP context update response at 56. Security functions are then performed between the MS and the New SGSN at 57. At 58, after traffic resumption, an HLR update is performed in accordance with the standard.

Two alternative embodiments are proposed to improve the MS-controlled cell change procedure:

a. The first alternative involves no change in the flow of signaling as shown in FIG 4. The only required modification is to keep track of the lost LLC frames at the Old SGSN 106 during RA Updates since these can be later tunneled to the New SGSN 107 (*i.e.*, an Acknowledge mode without retransmission). There is no need to maintain the whole buffer synchronization procedure.

b. The second alternative is to remove inter-SGSN tunneling and buffer synchronization, but keep the transfer of context information as shown FIG. 4. No TBF reassignment is used in this scenario.

Improvements Specific to Network-Controlled Cell Change: Three alternative embodiments are proposed to improve the Network controlled cell change procedure. FIG. 5 illustrates the most efficient embodiment. FIG. 6 illustrates the least efficient embodiment, although it is still an improvement over the prior art. FIG. 7 illustrates an embodiment whose efficiency lies between that of FIG. 5 and FIG. 6.

The embodiment of FIG. 6 improves on the RA Update interruption because of the pre-allocation of TBF and QoS, but a good fraction of the packets tunneled to the old SGSN may not be delivered to the MS after the cell change is ordered. The embodiment of FIG. 7 improves upon FIG. 6 because the removal of the tunneling avoids the setup time for the inter-SGSN tunnel. Therefore, the MS cell change is faster (the MS receives the cell change order earlier) while MS-destined packets are buffered at the new SGSN. However, FIG. 7 still offers a two-step interruption: (1) the interruption for setting up links between the GGSN and the new SGSN (with its associated buffering), and (2) the RA Update. Finally, FIG. 5 improves upon the process illustrated in FIG. 7 because the MS cell change is faster. The link between the GGSN and the new SGSN is actually changed at step 65, just prior to the cell change order, thus avoiding the execution of one primitive (SGSN context rsp at the new SGSN) with its associated buffering.

a. FIG. 5 is a message flow diagram illustrating the messages utilized in a first embodiment of an improved method of Network-controlled cell change. As shown in FIG. 5, the network initially treats the cell change request as a PDP update request. After the Old BSS 110 indicates it wants to perform a cell change at 59, the Old (serving) SGSN 106 sends a PDP context update request 60 to the GGSN 102 indicating that the currently used context needs to be configured at the new SGSN 107. The target cell is indicated in the request. The MS-terminated and originated RT speech packet transmission between the old SGSN 106 and GGSN 102 continues uninterrupted. The GGSN then initiates the GTP link establishment procedures 61 towards the New SGSN 107, including the MS context (with the QoS, etc.).

The New SGSN 107 then issues a Radio Resources (RR) reservation request 62 to the New (target) BSS 111 requesting an allocation of resources, for both mobility and user data payload, in the specified cells and for the specified QoS level and RAB.

The target BSS responds at 63 with the identifier of the allocated resources and associated QoS level. Once the GTP link is set, the MS context, and radio resources are set-up, the new SGSN 107, replies to the GGSN 102 with an Update PDP context response 64. The GGSN then directs the traffic from the Old SGSN 106 to the new SGSN, where the packets are buffered. The GGSN replies to the Old SGSN with an Update PDP context response 65.

Upon receiving the response 65, the Old SGSN 106 forwards a Modified PDP context request 66 to the MS 112 indicating that a change of cell is requested. The MS in turn accesses the new channel using the pre-allocated TBF and sends a Routing Area Update Request 67 to the New SGSN 107. Security functions are then performed at 68. Since the New SGSN previously acquired the context from the old SGSN and the GGSN GTP link set-up, the New SGSN immediately sends a Routing Area Update Accept 69 to the MS. Data transfer then resumes at 70 and packets are sent directly to the MS with minimum interruption. At 58, after traffic resumption, an HLR update is performed in accordance with the standard.

Thus, in this embodiment, the GGSN 102 controls the link re-establishment process between the Old SGSN 106 and New SGSN 107. The GGSN serves as the anchor point in the link re-establishment procedure between SGSNs in the same fashion that the SGSN anchors the link re-establishment procedure between own-controlled BSSs, and the Base Station Controller (BSC) anchors the link re-establishment between own-controlled Base Stations (BS). The anchors are, therefore, in control of the various links. This concept is not applied in the current GPRS procedures.

A network utilizing the present invention is thereby more proactive than in the current network-controlled cell change scenario. While the cell change is being requested, the network prepares for the new links to be configured and for QoS resource reservation and admission control. The New SGSN 107 is configured with the MS context (including QoS). The target BSS 111 is requested to allocate resources for the session's QoS. Concurrently, a new GTP link is set up between the GGSN 102 and New SGSN. The data stream transfer between the MS 112, serving (Old) SGSN and GGSN is not interrupted during execution of these procedures.

Once the configuration and link set-up procedures are completed, the MS 112 is ordered to make the cell change. Since the radio resources have already been allocated to the MS, the interruption time is reduced substantially. The Mobility management signaling procedures (such as the RA Update) are delayed until after the data transfer resumes.

The main advantage of this method is the pre-allocation of QoS resources at the New BSS 111 coupled with the ability of the MS 112 to start renegotiating the QoS profile in the event that the original service QoS is not satisfied.

The use of a modified Update PDP context request 60-61 and the RR reservation request 62 allows the MS 112 to be informed of the allocated QoS and to readily start to renegotiate and/or set the QoS profile with the new SGSN 107 and BSS 111. This is not feasible under the current GPRS procedures, where the new BSS and MS have no way of knowing the allocated QoS profile in the new SGSN. As shown in FIG. 2, the MS must currently wait until after it receives the necessary information in the RA Update accept message 42.

b. FIG. 6 is a message flow diagram illustrating the messages utilized in a second embodiment of an improved method of Network-controlled cell change. After the Old BSS 110 indicates it wants to perform a cell change at 71, the Old SGSN 106 sends an SGSN context indication 71 to the New SGSN 107. The New SGSN sends a PDP context update request 73 to the GGSN 102 indicating that the currently used context needs to be configured at the new SGSN. A Radio Resources (RR) reservation request 74 is sent to the New BSS 111 to pre-allocate radio bearers prior to the MS 112 change of cell. The New BSS responds at 75 with the identifier of the allocated resources and associated QoS level. The GGSN then sends a PDP context update response 76 to the New SGSN which sends an SGSN context indication acknowledgment 77 to the Old SGSN. Tunneling of packets then occurs between the New SGSN and the Old SGSN at 78.

At 79, the Old SGSN 106 issues a change cell order to the Old BSS 110 which is forwarded to the MS at 80. Tunneling is then stopped at 81. The MS sends an RA Update request 82 to the New SGSN which returns an RA Update accept message to the MS at 83. Data transfer is then resumed at 84, and security functions are

performed at 85. At 58, after traffic resumption, an HLR update is performed in accordance with the standard.

c. FIG. 7 is a message flow diagram illustrating the messages utilized in a third embodiment of an improved method of Network-controlled cell change. This embodiment is a variation of the embodiment shown in FIG. 6. Because tunneling is inefficient and packet loss is reduced substantially when the MS 112 accesses the new cell, the inter-SGSN tunneling 78 is removed in this embodiment to reduce complexity. After the Old BSS 110 indicates it wants to perform a cell change at 86, the Old SGSN 106 sends an SGSN context indication 87 to the New SGSN 107. The New SGSN sends a PDP context update request 88 to the GGSN 102 indicating that the currently used context needs to be configured at the new SGSN. A Radio Resources (RR) reservation request 89 is sent to the New BSS 111 to pre-allocate radio bearers prior to the MS 112 change of cell. The New BSS responds at 90 with the identifier of the allocated resources and associated QoS level. The GGSN then sends a PDP context update response 91 to the New SGSN which sends an SGSN context indication acknowledgment 92 to the Old SGSN. At 93, the Old SGSN issues a change cell order to the Old BSS 110 which is forwarded to the MS at 94. The MS sends an RA Update request 95 to the New SGSN which returns an RA Update accept message to the MS at 96. Data transfer is then resumed at 97. Security functions are performed at 98. At 58, after traffic resumption, an HLR update is performed in accordance with the standard. In this embodiment, the new SGSN 107 starts buffering packets as soon as packets are directed to it when the new GTP link is established.

It is thus believed that the operation and construction of the present invention will be apparent from the foregoing description. While the method shown and described has been characterized as being preferred, it will be readily apparent that various changes and modifications could be made therein without departing from the scope of the invention as defined in the following claims.

WHAT IS CLAIMED IS:

1. A method of reducing delay time for a mobile station being handed over from an old Serving GPRS Support Node (SGSN) to a new SGSN during a call handling a real-time payload in a General Packet Radio Service (GPRS) packet switched radio telecommunications network, said method comprising the steps of:

sending system information messages about a target cell for handover on a control channel in the mobile station's current serving cell;

selecting the target cell for handover;

requesting handover to the selected target cell;

stopping packet flow to the mobile station;

establishing an uplink and downlink temporary block flow (TBF) in the target cell;

tunneling data packets between the old SGSN and the new SGSN until a link is established between the new SGSN and a Gateway GPRS Support Node (GGSN);

establishing the link between the new SGSN and the GGSN;

restarting packet flow from the new SGSN to the mobile station;

performing GPRS security functions;

determining whether the mobile station is GPRS attached; and

updating mobile station location information in a home location register (HLR), upon determining that the mobile station is GPRS attached.

2. The method of reducing delay time of claim 1 wherein the step of sending system information messages about a target cell for handover on a control channel in the mobile station's current serving cell includes sending the system information messages on a Packet Associated Control Channel (PACCH) in the mobile station's current serving cell.

3. The method of reducing delay time of claim 1 wherein the step of sending system information messages about a target cell for handover on a control channel in the mobile station's current serving cell includes sending the system information messages during silent periods when no real-time payload is being

transmitted.

4. The method of reducing delay time of claim 1 wherein the step of sending system information messages about a target cell for handover on a control channel in the mobile station's current serving cell includes the steps of:

determining whether the mobile station is capable of supporting multiple time slots; and

sending the system information messages on a different time slot than the time slot carrying the real-time payload, if the mobile station is capable of supporting multiple time slots.

5. The method of reducing delay time of claim 1 wherein the step of establishing an uplink and downlink TBF includes reserving a TBF in the target cell for the mobile station prior to requesting handover.

6. The method of reducing delay time of claim 5 wherein the step of reserving a TBF in the target cell for the mobile station prior to requesting handover includes reserving resources in the target cell for the mobile station based on the mobile station's quality of service profile.

7. The method of reducing delay time of claim 5 wherein the step of reserving a TBF in the target cell for the mobile station prior to requesting handover includes modifying a Packet Cell Change Order message to assign the TBF in the target cell to the mobile station.

8. The method of reducing delay time of claim 5 wherein the step of reserving a TBF in the target cell for the mobile station prior to requesting handover includes modifying a Packet Time Slot Reconfigure message to assign the TBF in the target cell to the mobile station.

9. The method of reducing delay time of claim 1 wherein the steps of

determining whether the mobile station is GPRS attached, and updating mobile station location information in the HLR are performed after the step of restarting packet flow from the new SGSN to the mobile station.

10. The method of reducing delay time of claim 1 wherein the step of performing GPRS security functions is performed after the step of restarting packet flow from the new SGSN to the mobile station.

11. The method of reducing delay time of claim 1 further comprising, before the step of sending system information messages about the target cell for handover, the step of pre-allocating resources in neighbor cells to the mobile station.

12. The method of reducing delay time of claim 11 wherein the step of pre-allocating resources in neighbor cells to the mobile station includes pre-allocating resources in neighbor cells for a predetermined time period.

13. The method of reducing delay time of claim 11 further comprising the steps of:

informing the mobile station of a quality of service level that will be provided after handover by the pre-allocated resources; and

negotiating by the mobile station and the network, a new quality of service level prior to completion of handover.

14. A method of reducing delay time for a mobile station being handed over from an old Serving GPRS Support Node (SGSN) to a new SGSN during a call in a General Packet Radio Service (GPRS) packet switched radio telecommunications network, said method comprising the steps of:

selecting the target cell for handover;

requesting handover to the selected target cell;

stopping packet flow to and from the mobile station;

establishing an uplink and downlink temporary block flow (TBF) in the target

cell;

restarting packet flow from the MS to the new SGSN;

buffering in the new SGSN, packets flowing to and from the mobile station;

establishing a link between the new SGSN and a Gateway GPRS Support Node (GGSN);

restarting packet flow from the new SGSN to the MS and from the new SGSN to the GGSN;

performing GPRS security functions;

determining whether the mobile station is GPRS attached; and

updating mobile station location information in a home location register (HLR), upon determining that the mobile station is GPRS attached.

15. A method of reducing delay time for a mobile station being handed over from an old Serving GPRS Support Node (SGSN) to a new SGSN during a call in a General Packet Radio Service (GPRS) packet switched radio telecommunications network, said method comprising the steps of:

sending system information messages about a target cell for handover on a control channel in the mobile station's current serving cell;

selecting the target cell for handover;

reserving a TBF in the target cell for the mobile station prior to requesting handover;

requesting handover to the selected target cell;

stopping packet flow to the mobile station;

establishing an uplink and downlink temporary block flow (TBF) in the target cell;

establishing a link between the new SGSN and a Gateway GPRS Support Node (GGSN);

buffering in the new SGSN, packets flowing to and from the mobile station;

restarting packet flow from the new SGSN to the mobile station;

performing GPRS security functions after packet flow is restarted;

determining whether the mobile station is GPRS attached; and

updating mobile station location information in a home location register (HLR) after packet flow is restarted, upon determining that the mobile station is GPRS attached.

16. A method of reducing delay time for a mobile station being handed over from an old Serving GPRS Support Node (SGSN) to a new SGSN during a call in an integrated radio telecommunications network having a General Packet Radio Service (GPRS) packet switched portion and a circuit switched portion, said method comprising the steps of:

sending system information messages about a target cell for handover on a control channel in the mobile station's current serving cell;

selecting the target cell for handover;

reserving a TBF in the target cell for the mobile station prior to requesting handover;

requesting handover to the selected target cell;

stopping packet flow to the mobile station;

establishing an uplink and downlink temporary block flow (TBF) in the target cell;

establishing a link between the new SGSN and a Gateway GPRS Support Node (GGSN);

buffering in the new SGSN, packets flowing to and from the mobile station;

restarting packet flow from the new SGSN to the mobile station;

performing GPRS security functions after packet flow is restarted;

determining whether the mobile station is GPRS attached;

updating mobile station location information in a home location register (HLR) after packet flow is restarted, upon determining that the mobile station is GPRS attached;

determining whether the mobile station is International Mobile Station Identification (IMSI) attached; and

updating the mobile station's mobility management context in the circuit switched portion after packet flow is restarted, upon determining that the mobile

station is IMSI attached.

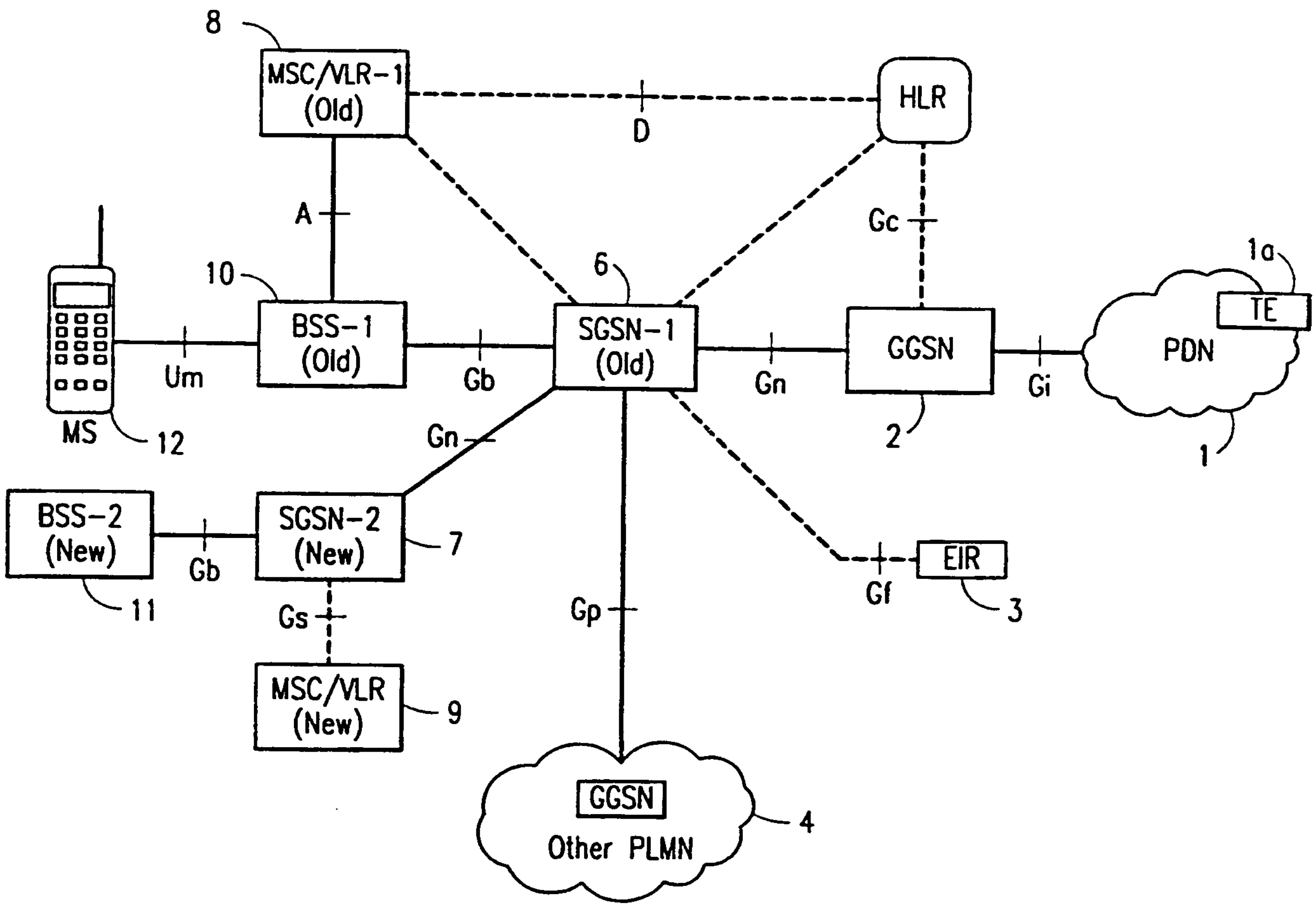


FIG. 1
(PRIOR ART)

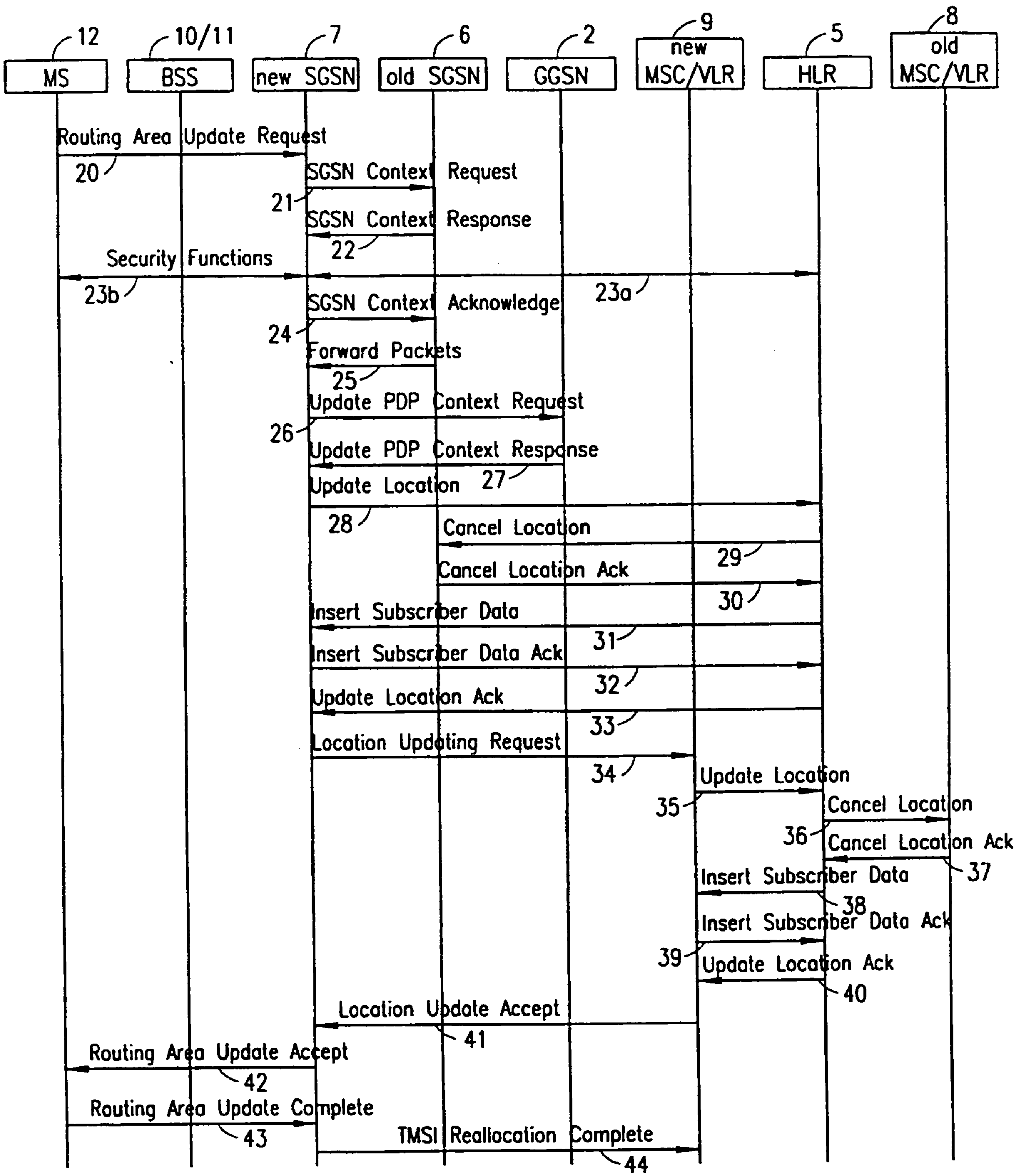


FIG. 2
(PRIOR ART)

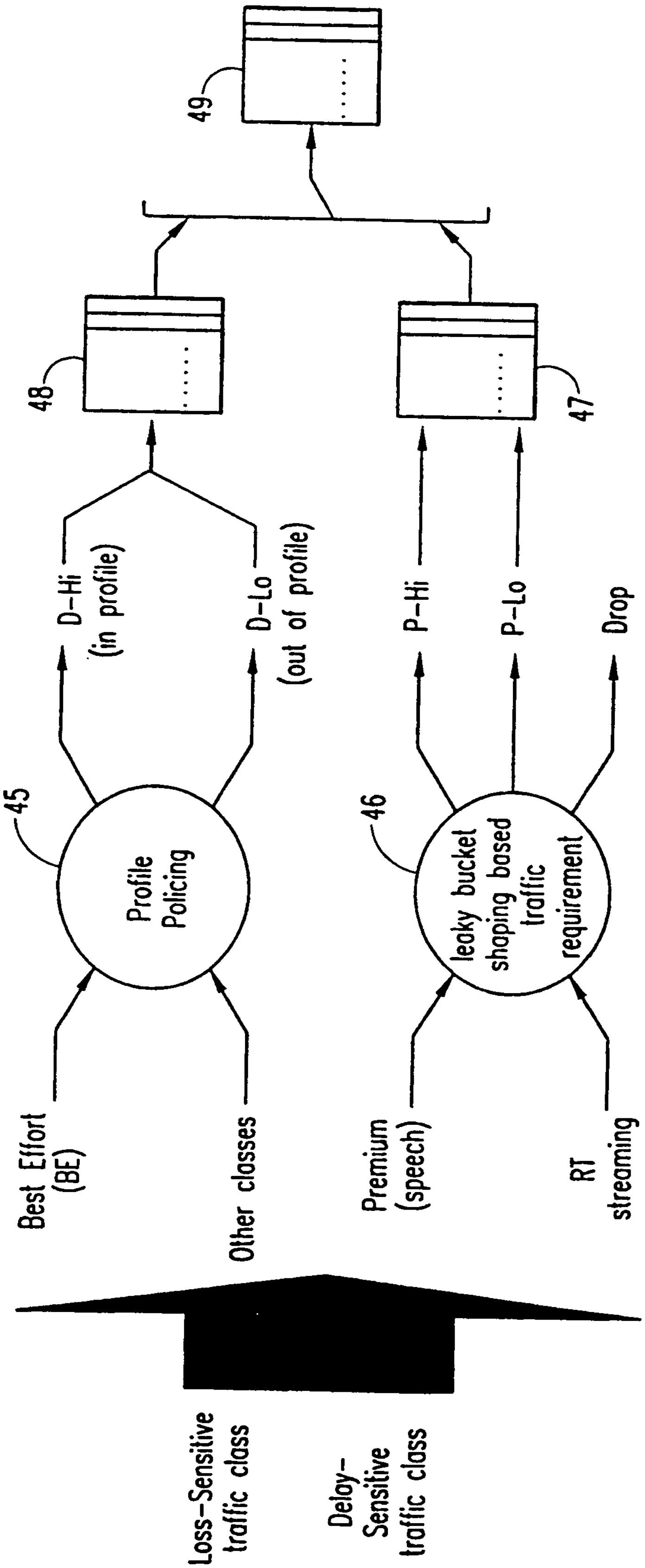

Loss-Sensitive traffic class
Delay-Sensitive traffic class
Best Effort (BE)
Other classes
Premium (speech)
RT streaming
Profile Policing
45
leaky bucket shaping based traffic requirement
46
D-Hi (in profile)
D-Lo (out of profile)
P-Hi
P-Lo
Drop
48
47
49

FIG. 3

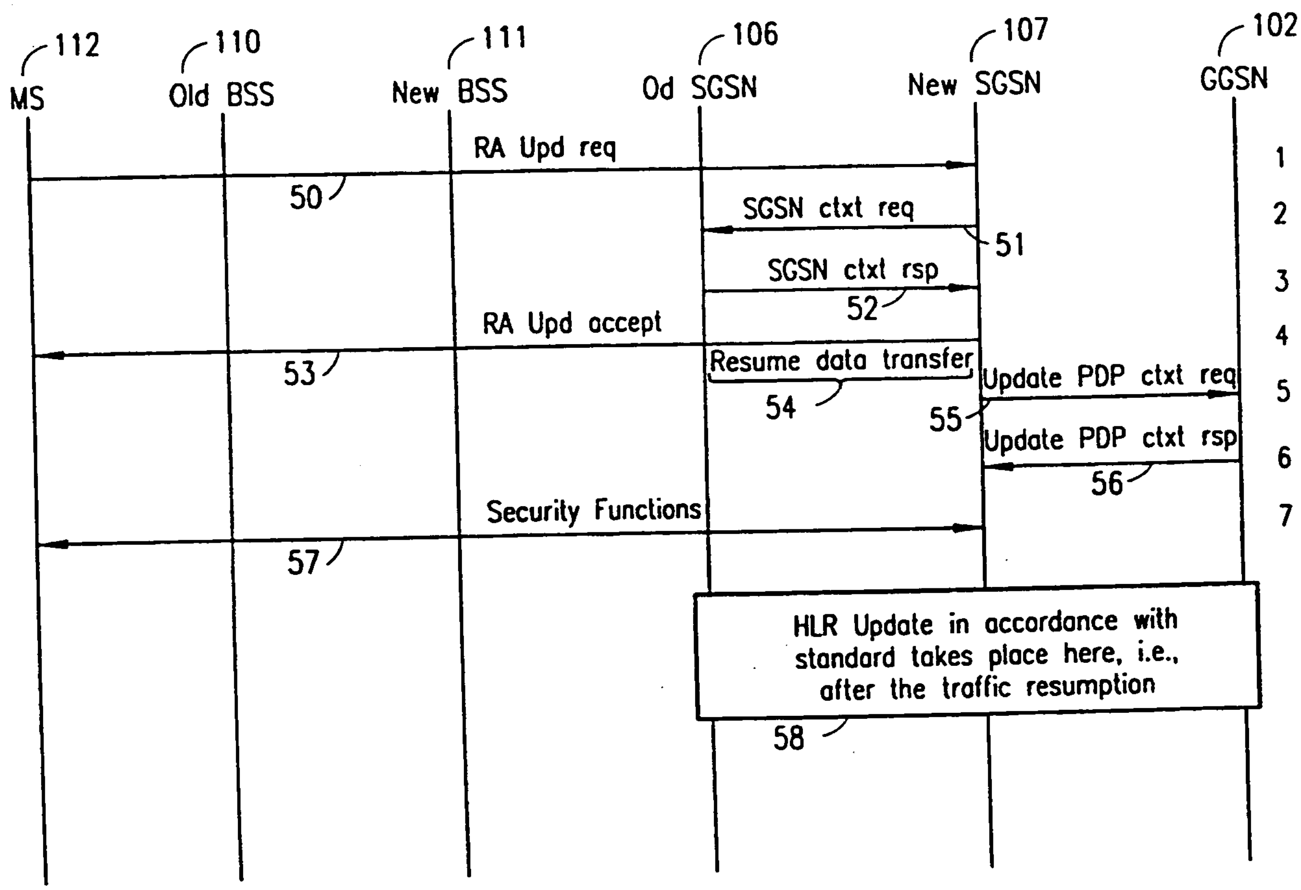

112
MS
110
Old BSS
111
New BSS
106
Od SGSN
107
New SGSN
102
GGSN
RA Upd req
50
1
SGSN ctxt req
51
2
SGSN ctxt rsp
52
3
RA Upd accept
53
4
Resume data transfer
54
55
Update PDP ctxt req
5
Update PDP ctxt rsp
56
6
Security Functions
57
7
HLR Update in accordance with
standard takes place here, i.e.,
after the traffic resumption
58

FIG. 4

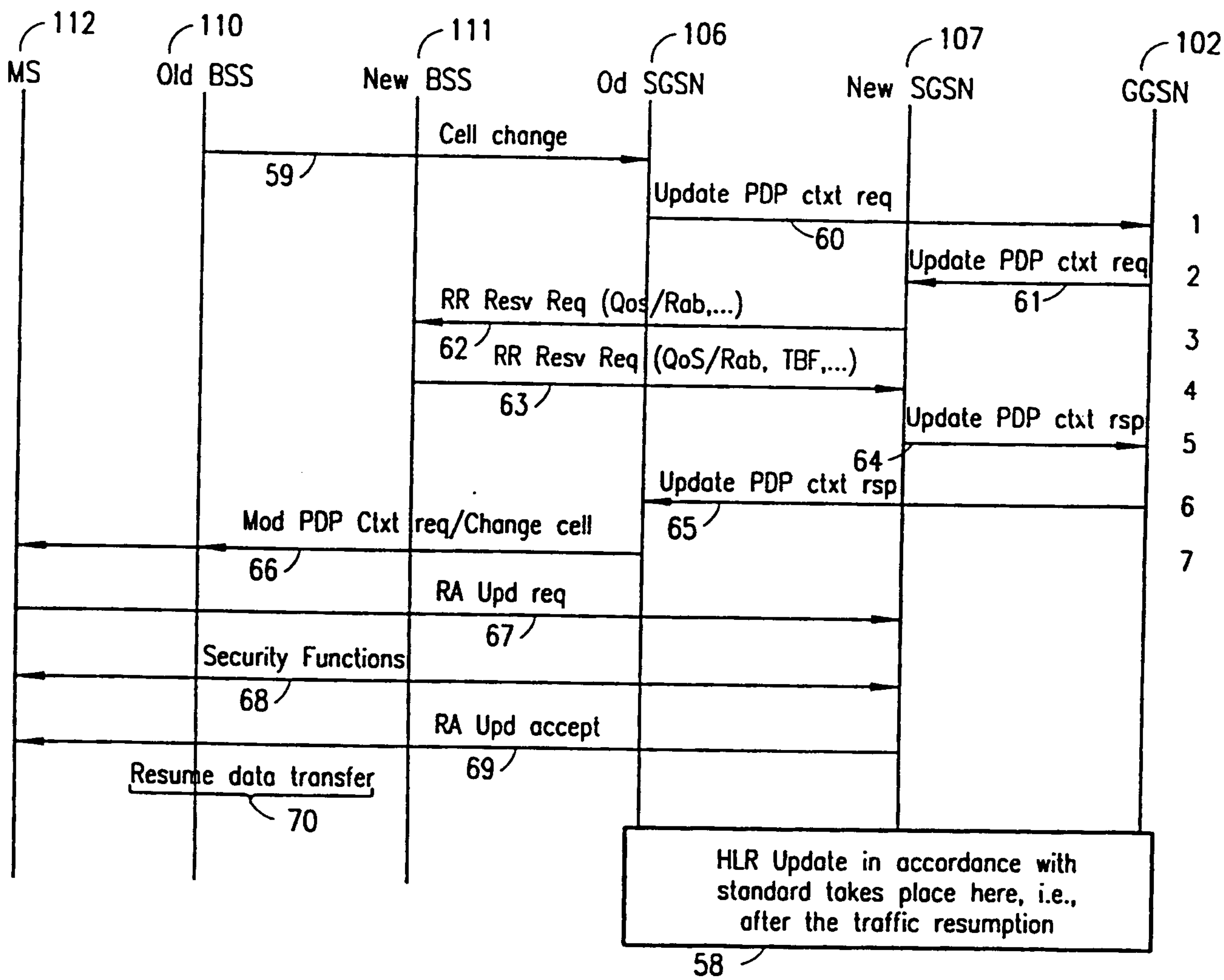

112
MS
110
Old BSS
111
New BSS
106
Od SGSN
107
New SGSN
102
GGSN
Cell change
59
Update PDP ctxt req
60
1
Update PDP ctxt req
61
2
RR Resv Req (Qos/Rab,...)
62
3
RR Resv Req (QoS/Rab, TBF,...)
63
4
Update PDP ctxt rsp
64
5
Update PDP ctxt rsp
65
6
Mod PDP Ctxt req/Change cell
66
7
RA Upd req
67
Security Functions
68
RA Upd accept
69
Resume data transfer
70
HLR Update in accordance with standard takes place here, i.e., after the traffic resumption
58

FIG. 5

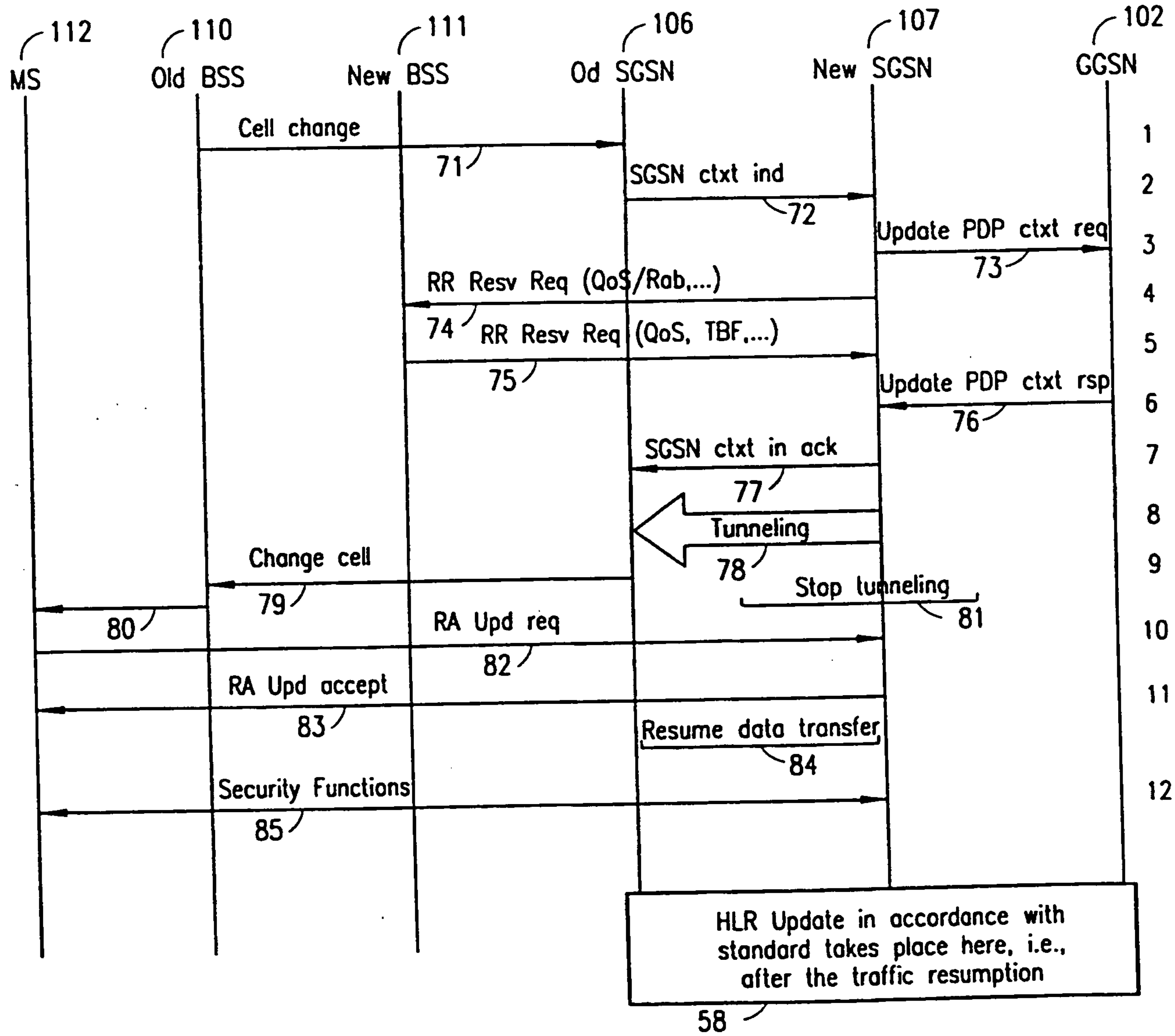
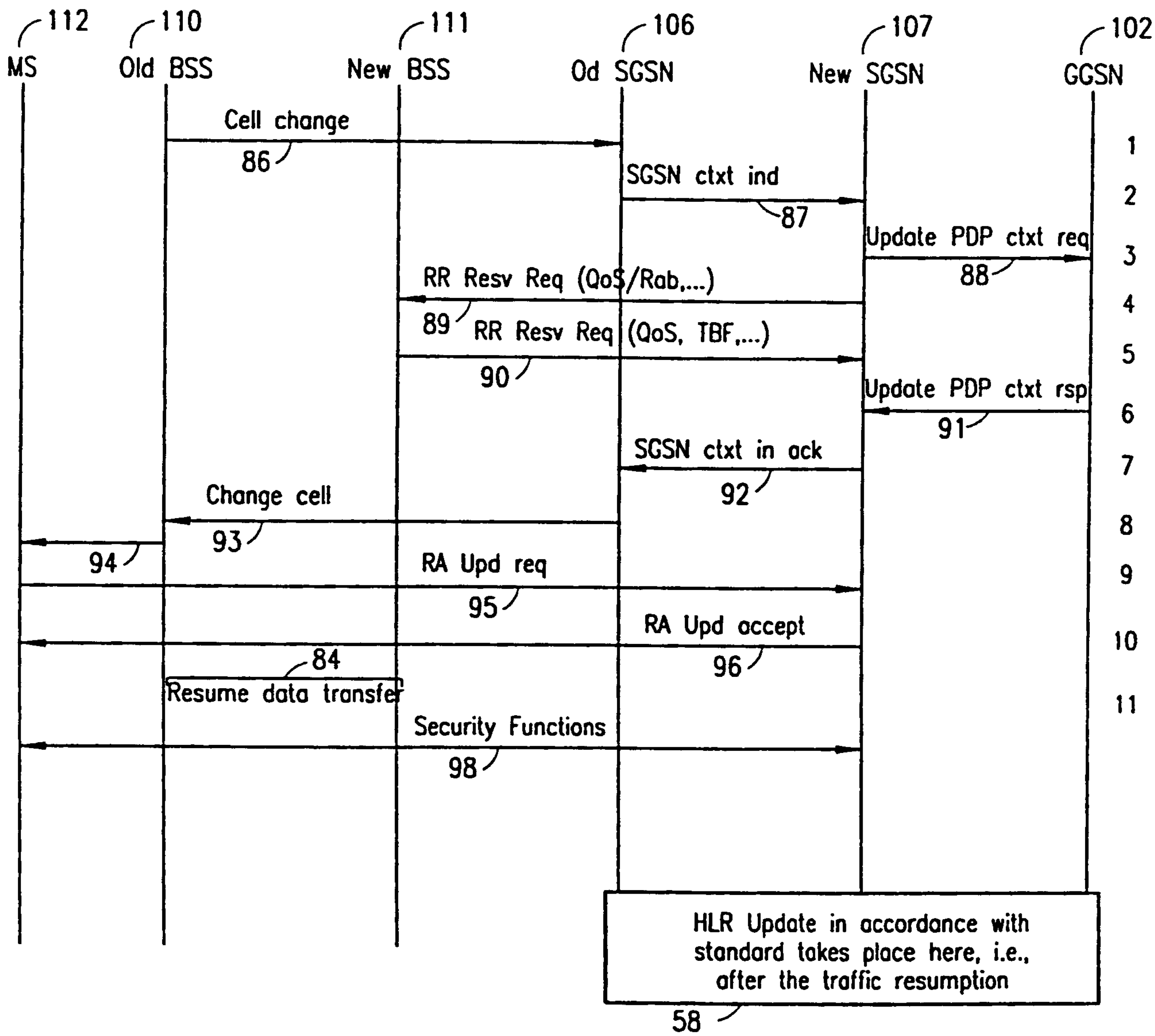

112
MS
110
Old BSS
111
New BSS
106
Od SGSN
107
New SGSN
102
GGSN
Cell change
71
SGSN ctxt ind
72
Update PDP ctxt req
73
RR Resv Req (QoS/Rab,...)
74
RR Resv Req (QoS, TBF,...)
75
Update PDP ctxt rsp
76
SGSN ctxt in ack
77
Tunneling
78
Change cell
79
Stop tunneling
81
80
RA Upd req
82
RA Upd accept
83
Resume data transfer
84
Security Functions
85
HLR Update in accordance with standard takes place here, i.e., after the traffic resumption
58
1
2
3
4
5
6
7
8
9
10
11
12

FIG. 6


112
110
111
106
107
102
MS
Old BSS
New BSS
Od SGSN
New SGSN
GGSN
Cell change
86
SGSN ctxt ind
87
Update PDP ctxt req
88
RR Resv Req (QoS/Rab,...)
89
RR Resv Req (QoS, TBF,...)
90
Update PDP ctxt rsp
91
SGSN ctxt in ack
92
Change cell
93
94
RA Upd req
95
RA Upd accept
96
84
Resume data transfer
Security Functions
98
HLR Update in accordance with standard takes place here, i.e., after the traffic resumption
58
1
2
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10
11

FIG. 7

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(74) Agent: NORIN, Klas; Ericsson Radio Systems AB, Common Patent Department, S-164 80 Stockholm (SE).

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(54) Title: METHOD OF HANDING OVER MOBILE STATIONS IN A GENERAL PACKET RADIO SERVICE (GPRS) RADIO TELECOMMUNICATIONS NETWORK

(57) Abstract: A method of improving cell change procedures within a General Packet Radio Service (GPRS) network to reduce the handover interruption time while keeping the delays to affordable values for real-time payload services. The data stream interruption is reduced at the air interface level and the core network level. Improvements at the air interface are achieved by reducing the system information retrieval time and pre-allocating the radio resources prior to the MS accessing the new cell. Improvements within the core network are achieved by shortening the inter-SGSN Routing Area Update interruption interval and implementing low latency delay-sensitive requirements and shaping packet traffic for premium traffic.

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International Application No
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A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04Q7/38

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B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
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Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 898 438 A (NOKIA MOBILE PHONES LTD) 24 February 1999 (1999-02-24) column 4, line 18 - line 34 column 9, line 43 -column 10, line 40 column 13, line 17 -column 14, line 18 ---	1-16
A	WO 98 32304 A (NOKIA TELECOMMUNICATIONS OY) 23 July 1998 (1998-07-23) page 13, line 30 -page 17, line 10 page 17, line 35 -page 18, line 28 ---	1-16
A	WO 98 59468 A (NOKIA TELECOMMUNICATIONS OY) 30 December 1998 (1998-12-30) page 5, line 20 -page 6, line 22 --- -/--	1-16

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
6 November 2000	18. 12. 2000

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/SE 00/01277

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DIGITAL CELLULAR TELECOMMUNICATIONS SYSTEM (PHASE 2+), - 21 July 1999 (1999-07-21) XP002901367 (Phase 2+); General Packet Radio Service (GPRS); Service description; Stage 2 (GSM 03.60 version 6.3.2 Release 1997)' ETSI EN 301 344 no. 6.3.2, page 47 -page 49 ---	1-16
P,A	EP 0 996 304 A (NORTEL MATRA CELLULAR) 26 April 2000 (2000-04-26) column 4, line 16 -column 5, line 32 column 9, line 6 - line 20 ---	
E	WO 00 44191 A (SUBBIAH BARANITHARAN) 27 July 2000 (2000-07-27) page 7, line 1 -page 9, line 3 page 12, line 8 - line 23 page 14, line 8 -page 17, line 11 ---	1,14-16
E	US 6 104 929 A (ESTEBAN MIGUEL COBO ET AL) 15 August 2000 (2000-08-15) column 11, line 30 -column 12, line 55; figure 4A ---	1,14-16
P,A	WO 99 66740 A (EINOLA HEIKKI) 23 December 1999 (1999-12-23) page 3, line 15 -page 4, line 29 page 21, line 6 -page 22, line 50 ---	1,14-16
P,A	WO 99 34635 A (ERICSSON TELEFON AB L M) 8 July 1999 (1999-07-08) the whole document -----	1,14-16

3

INTERNATIONAL SEARCH REPORT

International Application No
PCT/SE 00/01277

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0898438 A	24-02-1999	FI 973425 A	21-02-1999
		AU 7045198 A	08-03-1999
		BR 9811247 A	18-07-2000
		CN 1267440 T	20-09-2000
		FI 990988 A	30-04-1999
		WO 9909774 A	25-02-1999
		JP 11113071 A	23-04-1999
WO 9832304 A	23-07-1998	FI 970238 A	21-07-1998
		AU 5665998 A	07-08-1998
		EP 0953270 A	03-11-1999
		ZA 9800408 A	29-07-1998
WO 9859468 A	30-12-1998	FI 972725 A	25-12-1998
		AU 7920998 A	04-01-1999
		EP 0920761 A	09-06-1999
EP 0996304 A	26-04-2000	WO 0024213 A	27-04-2000
WO 0044191 A	27-07-2000	AU 2861500 A	07-08-2000
US 6104929 A	15-08-2000	AU 7946298 A	04-01-1999
		BR 9810447 A	05-09-2000
		CN 1267433 T	20-09-2000
		EP 0976271 A	02-02-2000
		WO 9859505 A	30-12-1998
WO 9966740 A	23-12-1999	AU 4554499 A	05-01-2000
WO 9934635 A	08-07-1999	NO 976150 A	01-07-1999
		AU 2193699 A	19-07-1999